PA.19 Fuel Injector Optimization for NO_x and LOI Control

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Abstract

Reaction Engineering International (REI) has established a project team of experts to develop a technology for combustion systems which will minimize NO_x emissions and minimize carbon in the fly ash. This much needed technology will allow users to meet environmental compliance and produce a saleable by-product. The team consists of REI experts in NO_x formation and control and combustion modeling; Dr. Robert Hurt (Brown University), an expert in char reactivity;

Dr. Joseph Klewicki (University of Utah), and expert in two-phase mixing; Riley Stoker Corporation, experts in firing systems; and the Electric Power Research Institute (EPRI), an industrial partner to maintain focus on the end-user.

This study is concerned with the NO_x control technology of choice for pulverized coal fired boilers, "in-furnace NO_x control," which includes: staged low-NO_x burners, reburning, selective non-catalytic reduction (SNCR) and hybrid approaches (e.g., reburning with SNCR). The program has two primary objectives: (1) to improve the performance of "in-furnace" NO_x control processes; (2) to devise new, or improve existing approaches for maximum "in-furnace" NO_x control and minimum unburned carbon.

The program involves: (1) fundamental studies at laboratory- and bench-scale to define NO reduction mechanisms in flames and reburning jets; (2) laboratory experiments and computer modeling to improve our two-phase mixing predictive capability; (3) evaluation of commercial low-NO_x burner fuel injectors to develop improved designs, and (4) demonstration of coal injectors for reburning and low-NO_x burners at commercial scale.

The specific objectives of the two-phase program are to:

1) Conduct research to better understand the interaction of heterogeneous chemistry and two phase mixing on NO reduction processes in pulverized coal combustion.

2) Improve our ability to predict combusting coal jets by verifying two phase mixing models under conditions that simulate the near field of low-NO_x burners.

3) Determine the limits on NO control by in-furnace NO_x control technologies as a function of furnace design and coal type.

4) Develop and demonstrate improved coal injector designs for commercial low-NO_x burners and coal reburning systems.

5) Modify the char burnout model in REI's coal combustion code to take account of recently obtained fundamental data on char reactivity during the late stages of burnout. This will improve our ability to predict carbon burnout with low-NO_x firing systems.

The commercial products resulting from this effort will not only include improved fuel injector hardware for low-NO_x firing systems, but also improved computational tools to help the utility boiler operator determine the optimum low-NO_x firing configuration taking account of both corrosion potential and increases in unburned carbon.

Computer simulation is central to the program, providing both data evaluation and generalization. The two-phase mixing studies carried out at the University of Utah were planned to develop data to validate the two-phase mixing models in *GLACIER*. The two phase experimental system is now being used to help develop fuel injection hardware by screening designs to determine how to optimize particle mass distribution at the injector exit as a function and particle size.

Studies at Brown University are concentrating on two aspects of char reactivity with respect to char oxidation and the reduction of NO. In Phase I, the emphasis was on the development of an advanced burnout model that could be integrated with *GLACIER* and the construction of an apparatus that would allow the hypothesis to be tested that young chars have a higher potential to reduce NO than old chars. This is currently being investigated.

The combustion testing in Phase I was carried out at the University of Utah in bench- and pilot-scale facilities. The work is continuing and will be augmented by full-scale testing at DB Riley on the U-Furnace Test Facility with the LEBS Firing System.

In Phase I, the simulation task concentrated on fuel injection systems and on the evaluation of advanced burnout models for predicting LOI from low-NO_x firing systems. Currently there is more emphasis on evaluating pilot-scale data; but full system simulations are anticipated since computer modeling is the only way to evaluate multiple burner effects at scale.